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ABSTRACT

Three experimental studies were carried out to examine the ability of groups of learners of English as a second language to solve problems of deductive reasoning (three term linear syllogisms) in their native and second languages. In the first study involving Canadian francophones studying English, subjects solved problems more effectively in their native than in their second language. Their skill in carrying out the experimental task in English was not a function of their competence in that language. In a second study with Canadian francophone subjects the methodology was refined and multivariate statistical techniques were used to analyse the data. The findings confirmed the general pattern of results in the first study and made it possible to locate an information processing difficulty in the second language at the second stage of the problems. Study three was carried out with Arabic-speaking learners of ESL. Once again a similar pattern of results was found. Data from the three studies suggest that second language proficiency scores may not be a very sound predictor of an individual's ability to be educated or to perform certain other tasks in a second language. (Author/AMH)

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Solving Problems in Deductive Reasoning: Three Experimental Studies of Adult Second Language Learners

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In this paper we describe three experimental studies designed to investigate the ability of adult second language learners of varying levels of proficiency to solve elementary problems of deductive reasoning in their mother tongue and in their weaker language. The purpose of the series of experiments was to examine the impact on incipient bilinguals of performing certain information processing skills in a second language.

Impetus for this research has come from the authors' observations that in countries throughout the world many individuals are called upon to work or to study in a language other than that spoken at home. According to Dornic (1977) the tendency towards multilingualism , which is an important characteristic of the modern world, is a natural consequence of technological and cultural developments of the past decades. In a typical industrialized country of the seventies, he reports, at least one-eighth of the inhabitants receive, store, organize and use information in languages differing from their dominant language. For example, at the present time, large numbers of Canadians are finding it necessary or desirable to study through the medium of a second language. Many English-speaking children in Canada are enrolled in "Immersion" programs in which French, the second language, is used as the principal medium of instruction. On the other hand French-speaking university students in various disciplines find themselves obliged to work with English language textbooks. A survey of the library holdings at Laval University, a French language institution in Quebec City (Smith, 1972), revealed that approximately 75 percent of the 30,948 volumes in the library were English. Likewise, the university calendar for the faculty of science revealed that 74 per cent of the recommended undergraduate texts were in English. The situation is by no means unique to Canada. To cite an example from an other part of the world,students in the professional faculties of the universities of Egypt, Jordan, Kuwait and the Sudan are expected to follow their courses and write their theses in English. Reports such as these make it quite clear that systematic studies of the ability of bilinguals (and we use the term to mean persons possessing varying levels of skill in the second language, c.f., Macnamara, 1967) to

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process written information may have both theoretical and practical implications.

A number of authors have presented evidence that certain cognitive processes may not function so efficiently in the bilingual's second language as in his mother tongue (for a review, see Dornic, 1977). Macnamara (1966) studied the ability of bilingual Irish children in grades five and six to solve problems presented to them in English, their mother tongue and in Irish, their second language. The children were equally accurate in solving the two sets of problems but were significantly slower in their weaker language. The results of this study and of others focusing on the reading and problem solving skills of bilinguals caused Macnamara to conclude that bilinguals do not process information as efficiently in their second language as in their mother tongue even when the material involves familiar vocabulary and syntax. He attributed the difficulty to the burden placed on short term memory by the greater attention the bilingual must pay to incoming material expressed in the weaker language.

In a developmental study of free recall in bilingually educated children, Frender (1975) found that subjects performed significantly better on lists presented in English, their mother tongue, than in their weaker language, French. Furthermore, there was no systematic tendency for the size of the language difference to diminish across the first six grades, as the children acquired greater skill and experience with the second code.

A similar pattern of results was reported in a study carried out by d'Anglejan and Tucker (1973) in which skilled professional translators were required to complete "cloze" passages in their native and second languages. In spite of their high level of sophistication in both languages, native speakers of French performed significantly better in French, while the converse was true for native speakers of English. These results were somewhat puzzling since it was predicted that the translators' high level of second language proficiency and the type of task involved in translation would have equipped them to draw with maximum efficiency on semantic and syntactic probabilities. Some additional cognitive skill appeared to be involved, and this skill clearly seemed to be affected when the information processing task involved material presented in the second language.

The present series of experiments was designed to examine: 1) the relative ability of bilinguals to perform problem-solving tasks in their two languages and 2) the relationship between the bilinguals' measured level of second language proficiency and their success in the experimental tasks. The three studies involved problems of deductive reasoning or linear syllogisms. According to Clark (1969), solving a problem in deductive reasoning involves four identifiable stages: a) comprehension of the deep structure of the propositions, b)compre-

hension of the question, c) a search for the information asked for in the question; and d) the formulation of an answer. Language plays an important role in the process, one which transcends the simple comprehension of the words themselves and calls upon higher order representational and integrative schemes.

Deductive reasoning problems involve extremely simple vocabulary and familiar syntax, e.g.,

> If Bill is better than John
> and John is better than Tom,
> who is the best?
>
> Bill John Tom

They vary in complexity from the simplest form described above to somewhat more complex forms involving negative-equative propositions such as:

> If Bill is not as bad as John,
> and John is not as bad as Tom,
> who is worst?
>
> Tom John Bill

In certain instances the question is congruent with the propositions of the problem. In others, the question and propositions are incongruent. Familiar proper nouns are used in the problems and they are varied so as to give no clues to the correct response.

These problems seemed particularly well suited to our purpose, since the translated forms are word for word equivalents of the English version. Thus we are able to construct equivalent French-English sets (studies one and two) and Arabic-English sets (study three) involving the same syntactic forms. In addition, these problems are interesting because they draw upon fundamental reasoning skills which are involved in many everyday situations and in academic tasks such as arithmetic problems or multiple-choice examination questions.

We are familiar with the extensive research literature relating to the psychology of reasoning (see, for example, Wason & Johnson-Laird, 1972), and we have adapted the stimulus materials from some of these studies for use in our studies. We purposely did not attempt to integrate our work into any specific theoretical framework, since this was extraneous to answering the pragmatic questions which prompted the experiments.

STUDY ONE

Our first experiment was part of a broader investigation of diverse linguistic and cognitive aspects of second language acquisi-

tion in adults (see also d'Anglejan-Chatillon, 1975).

Subjects

All subjects (Ss) for the experiment were male military personnel attending the language school at the Canadian Forces Base in St-Jean, Quebec. There were two experimental groups -- beginners (BEG) and advanced (ADV) -- of twenty Ss each comprising French Canadians who were studying English as a second language.

Subjects in both groups filled out a background questionnaire designed to determine their level of education and amount of exposure to English. The average age of the Ss in the BEG group was 19.7 years; and in the ADV group it was 24.55. Both groups had completed an average of 12 years of formal schooling. The BEG had received an average of 4.75 years of instruction in English as a second language, as compared with an average of 4.90 for the ADV group. Subjects in both groups reported that their teachers of English had followed mainly traditional grammar-translation methods, supplemented in some instances by conversation practice. None had followed audio-lingual programs during their school years. Thirty percent of the BEG and fifty percent of the ADV students reported having had occasion to improve their English outside school through contacts in the English-speaking community. When asked to evaluate their own competence in reading, writing, speaking and understanding English, the average ratings of the ADV students were consistently higher than those of the BEG. Only two of the twenty BEG students had studied an academic or professional subject taught in English. Twelve of the ADV students reported having done so. This is an interesting finding in that our two experimental groups had received a similar amount of formal instruction in English, yet formal tests of their English language skills administered by the language school clearly placed them in separate groups. It may be that the opportunity to study subject matter in the second language rather than the number of years they have studied the language *per se* has been a critical factor influencing their achievement in English. This would replicate findings reported by Saegert, Scott, Perkins and Tucker (1974).

The BEG students were enrolled in a basic English course, an intensive twelve week audio-lingual program involving approximately five hours of instruction per day. All Ss had been given diagnostic tests of their abilities in reading, writing, understanding and speaking English before being assigned to classes, and these scores were placed at our disposal by the school testing officer. These tests are similar in format to those used by the Foreign Service Institute in the United States.

The ADV students were also following an intensive twelve week course of study, but their program differed from that of the BEG in that it emphasized the improvement of reading and writing abilities as well as speaking skills.

Test Materials

Appendix 1 shows the format of the 32 problems that we used. Equivalent sets were constructed with the adjective pairs good/bad and tall/short. This was done to avoid monotony. Familiar proper nouns were used in the problems, and they were varied so that they gave no clues to the answers to the problems. The problems were typed on blank IBM cards in the following form:

> If Bill is better than John,
> and John is better than Tom,
> who is best?
>
> Bill Tom John

Each S received the following array of stimulus items: a) in English, 16 problems involving tall/short; 16 involving good/bad; b) in French, 16 problems involving grand/petit; 16 involving bon/mauvais. The order of presentation was counter-balanced so that half of the Ss in each group received the English problems first while the other half began with the French set. Likewise the choice of the tall/short and good/bad problems was counter-balanced so that all Ss had all types of problems, half expressed with good/bad and half with tall/short. We purposely separated the English and French sets to avoid confusion; but the problems within a set were shuffled for each S to minimize practice effects.

Method

The Ss were seated beside the experimenter (E), and the first set of problems was placed face down on the table. The procedure was explained by E, and S solved a few practice problems. These cards were then replaced near the bottom of the deck. When S said he understood the task, the test began. The S turned over the top card on the deck. As he placed it face up, E activated a chronometer by depressing a lever. When S gave the answer to the problem, E removed her finger from the lever and the latency was recorded on an answer sheet beside the appropriate problem number. The response was also entered. When both E and S were ready, the next card was turned over and this routine was followed until the entire set of problems had been completed. Subjects were then free to return to their classes, or to perform some unrelated task for a few hours before being presented with the second set of test items.

Analysis of the data

Latency and error scores for each group were calculated. Separate two-way analyses of variance were carried out on the mean scores for both measures. The independent variables were group membership (BEG and ADV) and language of testing (English or French). The dependent variables were the latency scores and the error scores.

Results and Discussion

The analysis of variance carried out on the latency scores showed no significant main effect for language and no group by language interaction. These data were difficult to interpret since our measuring instrument lacked precision and we had no information on the comparability of the French and English problems in terms of reading latencies. Furthermore, the time taken by Ss to read the problems was confounded with time taken to solve them.

The analysis of variance performed on the error scores for the two groups showed a significant main effect for language (F 5.74; 1,38 df; $p < .05$). The Ss in general made fewer errors in solving problems presented in French ($\bar{X} = 5.67$ out of 32) than they did when the same problems were presented in English ($\bar{X} = 7.05$). The main effect for group was not significant, nor was the group by language interaction. This suggests that the members of our two groups were equally able to solve such problems. The incidence of error was relatively low and the ADV group's greater knowledge of English did not result in their making significantly fewer errors. An interesting analogy can be drawn between this finding and experimental evidence reported by Tuinman and Brady (1973). In a reading comprehension task given to children, these researchers found that thorough pretaining on vocabulary items from a reading passage did not raise the comprehension scores of children in grades 4 to 6. Clearly, a certain minimal knowledge of the relevant vocabulary is a necessary prerequisite for successful performance on information processing tasks, but it appears that this knowledge per se is not sufficient to improve performance beyond a certain level. One would assume that with increasing maturity the performance of the children would eventually improve. But it is not clear whether the performance of our second language learners would follow a similar developmental pattern, since there was no significant difference between the performance of the BEG and ADV groups in spite of the latter's superior command of the second language. Since we did not have a comparison group of skilled bilinguals with whom to make comparisons, the question could not be answered. Cummins (1977a) recently drew attention to the importance of including a control group of skilled bilinguals in studies of the cognitive functioning of incipient bilinguals.

STUDY TWO

The second experiment was conducted to replicate and extend the findings of study one. We wanted to look more carefully at some of the operations involved in the experimental task in order to pinpoint at what point in the problem solving process the task might prove taxing in the second language. This required the use of more precise apparatus for the measurement of latencies. In addition, we included among our experimental subjects a group of skilled bilinguals to determine whether effects noted at various stages of proficiency were transitory or more durable.

Subjects

The subjects comprised three experimental groups, 25 beginners (BEG) and 25 advanced (ADV) students of ESL and 20 bilingual (BIL) teachers in the Language Bureau of the Public Service of Canada. All were native speakers of French. A background questionnaire was administered in French to collect information such as the following: respondents' age, formal training in English, self-ratings of English proficiency and degree of exposure to English in the community.

Table 1 shows the mean age, amount of formal education, years of formal study of English and contact with the English community for the three groups. Self ratings of ESL proficiency are presented in Table 2.

Table 1

Background information on experimental groups

	BEG	ADV	BIL
Average age	23.84	27.16	31.85
Years of formal schooling	11.92	13.00	16.80
Years of ESL study	6.48	6.44	13.30
Proportion of Ss reporting contacts with English in the community	.08	.28	.90

Table 2

Mean self ratings for ESL proficiency (7 point scale extending from "parfaitement" = 1 to "pas du tout" = 7)

	BEG	ADV	BIL
Read English	4.20	3.64	1.60
Write English	4.28	4.00	2.40
Speak English	5.08	4.00	2.00
Understand English	4.52	3.48	1.50

As in study one, years of formal ESL study alone did not constitute a good predictor of ESL proficiency for the learner groups since tests administered by the Language Bureau clearly placed the BEG and ADV Ss in separate groups. This measure did, however, distinguish the BIL group from the other two. Since ESL is rarely taught in French Canada before grade 5 it is likely that the BIL S's training involved university level courses in English language and/or literature. Once again, contacts with the English community show up as an important correlate of second language proficiency.

It is evident from these data that the BIL group, who were in fact teachers of French as a second language at the language school, differ in terms of age, education and years of formal study from the BEG and ADV Ss. This difference could not be avoided since for obvious reasons the ESL student population did not include skilled bilinguals. To confirm the BIL's self-ratings of English proficiency we administered a cloze test to this group. Ratings were within the range found for a group of native speakers in previous research (d'Anglejan-Chatillon, 1975).

Method

The methodology in this study differed from that used in Study One in that the entire process was mechanized. Problems were presented via a "BCI" SR-400 Stimulus Programmer with a four choice console. Response latencies in the form of a sound signal were transmitted via an EICO Audio Generator to a Sony tape recorder. A Bruel and Kjaer Level recorder was used to produce a response latency graph which was then converted into seconds.

A second important methodological innovation was introduced in order to gain more precise information concerning the locus of any information processing differences between problems in the native and second languages. Research carried out by Potts and Scholz (1975) has shown that the solving of three-term series problems can effectively be broken down into two separate stages. By presenting the first two premises of the problem before the question, separate latencies can be obtained for the time taken by Ss 1) to encode and generate an internal representation of the problem and 2) to produce a response. Thus in the first stage, the Ss pressed a key on the console which automatically presented the first part of the problem, e.g.,

> If John is better than Bill
> and Bill is better than Tom.

When the S had finished reading this information he again pressed a lever which simultaneously registered a first latency score, removed the first two premises from sight, and presented the second stage of the problem, the question "Who is best?" or "Who is worst?", and the three possible answers

Tom Bill John

The answer was noted when S pressed a key corresponding to the correct response among the three alternatives. At the same time a second latency score was registered.

In this way, we were able to get a separate latency score for the time taken by our Ss to comprehend and store the premises of the problem and for the time taken to search back through the stored information and produce an answer. Our equipment was sufficiently sensitive to be able to record times as short as 0.04 sec.

Subjects went through a practice run to familiarize themselves with the nature of the test problems and the operation of the equipment. The test battery comprised:

a) 32 French problems involving the adjectives bon/mauvais, and

b) 32 English problems involving the adjectives good/bad.

Four alternative counterbalanced orders of presentation were used in order to neutralize the effect of practice and problem-type on the Ss' performance.

Analysis of the Data

Mean latency scores for reading the problems and for solving the problems as well as error scores were computed for the three experi-

mental groups. Separate scores were calculated for problems presented in French and in English. A multivariate analysis of variance with repeated measures was carried out. The independent variable was group membership (BEG, ADV, BIL), and language (native language, second language) constituted the repeated measure. The dependent variables were mean error scores, mean latency scores for reading the problems and mean latency scores for solving the problems.

Results and Discussion

Table 3 shows the mean and variance observed for the 70 subjects. It is interesting to note that the variance observed in the second language data is of the same order of magnitude as that observed in the native language data for both error scores (20.54: 34.26) and for latency scores on reading (42.06 : 45.21). In contrast, latency scores for solving problems show a much greater ratio of variance (.51 : 1.28) for second language data than for native language data. These findings suggest that at the second stage of the problems Ss were differentially affected by working in a second language. Had all Ss been equally affected, only the mean and not the variance would have been expected to change.

Table 3

Overall Mean and Variance scores for latency and errors in native and second language

		Native language		Second language
Comprehension latency (secs)	$\bar{X}$	16.25	$\bar{X}$	17.68
	σ^2	42.06	σ^2	45.21
No. of errors	$\bar{X}$	4.5	$\bar{X}$	5.47
	σ^2	20.54	σ^2	34.26
Solution latency (secs)	$\bar{X}$	1.35	$\bar{X}$	1.57
	σ^2	.51	σ^2	1.28

Table 4

Mean latency and error scores for the three experimental groups in their native and second languages

Native = French
Second = English

	BEG N = 25	ADV N = 25	BIL N = 20
Comprehension latency - Native (secs)	17.19	16.27	15.03
Comprehension latency - Second (secs)	19.24	17.85	15.51
No of errors - Native	4.68	5.72	2.75
No of errors - Second	8.12	5.20	2.50
Solution latency - Native (secs)	1.41	1.45	1.14
Solution latency - Second (secs)	1.85	1.48	1.34

As a first step in data analysis a multivariate analysis of repeated measures was conducted by focusing on the sum and difference scores in the native and second language for each of the three dependent variables (error scores, latency scores for reading and latency scores for solving problems). The multivariate tests for group differences among the three experimental groups BEG, ADV and BIL were partitioned so as to consider 1) differences between the BIL Ss and the other Ss; and 2) differences between the BEG Ss and the ADV Ss. Roy's largest root criterion was used for the multivariate F-tests.

The overall multivariate analysis of the repeated measures showed no difference between the BEG Ss and the ADV Ss ($F = 0.8268$; $p = 0.5537$). In comparing these two groups there were neither significant group by language interactions nor group effects for any of the dependent variables indicating that 1) differences between Ss' ability to solve problems in their native and second language did not vary significantly with

proficiency in their second language and 2) the Ss' overall competence in these tasks did not differ significantly for the two groups.

The overall multivariate test did show a significant difference between BIL Ss and the other two groups ($F = 2.1161$; $p = 0.0001$). However this effect was concentrated in the overall error score ($F = 8.6878$; $p = 0.0045$). The BIL group made fewer errors than the other Ss in both the second and the native languages.

The sum of the native and second language latency scores for solution were considered as a covariate in a step-down analysis. A significant effect (F stepdown $= 5.8701$; $p = 0.0182$) for language was noted for problem solving latencies. Working in the second language differentially affected the S's performance, with regard to solution latencies.

These results, which are in concordance with the difference in observed variance for the entire 70 experimental Ss appear to suggest that for some individuals this type of information processing task places a burden on short term memory and retrieval capacities. According to Perfetti and Lesgold (1977), slow verbal coding strategies and short term memory limitations characterize the less skilled reader. In our experimental task such individuals might encounter difficulty in relating the third term of the syllogisms to the first two premises stored in short term memory. The capacity to do so appears to be taxed more greatly when the information being stored and manipulated is presented in a second language. It is particularly interesting to note that this effect was not related to the second language proficiency levels of our experimental groups.

The fact that error scores for the BIL group showed less of a language difference than did those for the BEG and ADV groups is difficult to interpret. Have the BIL Ss attained a threshold level of language proficiency which enables them to be only minimally affected by working in second language? Dornic (1977) has proposed that skilled bilinguals may develop sophisticated compensatory strategies enabling them to appear to function equally effectively in their weaker language. On the other hand, differences between the BIL and the other two experimental groups in terms of formal education, informal use of English and possibly even I.Q. may have had an impact on their overall ability to handle this type of task as evidenced by their comparatively lower error scores in both languages.

STUDY THREE

This study was conducted in an attempt to replicate the results of Study 2 under very different conditions. The study was carried out

in Egypt with two groups of Arabic-speaking students of English as a second language who were selected to represent relatively advanced and intermediate learners. We followed as carefully as possible the general procedure developed for Study 2 although we did not have available the mechanical aids, timing devices, etc., used in that study. Thus, our measures, although similar to those in Study 2, involved much grosser discriminations. This did not particularly concern us because we believed that we were examining the application by bilinguals of very basic cognitive strategies to a set of abstract problems and we hoped that the general pattern of results found in Study 2 would be robust enough to withstand such differences as discrepancies in languages involved, possible differences in learners' relative language proficiency, and the absolute accuracy of measurement techniques.

Subjects

The subjects (Ss) were 19 students in the English Language Institute (ELI) and 11 students in the Freshman Writing (FWC) of the American University in Cairo. The two samples were selected from the population of students who took the Michigan Test of English Language Proficiency at the beginning of the 1976-77 academic year as an entrance requirement for the regular university program. The ELI group consisted of 19 Ss whose scores ranged from 48% to 71% on the Michigan Test. Because of their low scores, they were enrolled in an intensive English language program at the ELI. The FWC group consisted of 11 Ss whose scores ranged from 82% to 97% and who had directly entered the regular university program. All Ss were native speakers of Arabic. The ELI group had studied English for an average of 11.05 years; the FWC, for 11.89 years. The Ss' ages ranged from 17 to 22.

A 27-item background questionnaire was administered in Arabic to Ss to collect information such as the following: respondent's age, formal training in English, parents' language background, self-rating of English proficiency, satisfaction with various aspects of formal English learning at school, motivational orientation, as well as information about the usefulness and necessity for English.

Method

The experimental task was similar to that employed in Study 2. It was designed to investigate the Ss' ability to solve problems of deductive reasoning via English, a weaker language, in comparison to their performance on a similar set of problems in Arabic, their native language. The experimental task comprised 32 three-term series problems.

As in the previous studies, all problems involved simple vocabulary and posed no difficulty for the Ss at the lexical level. The propositions were divided into three sets varying in complexity from: 1) the very simple form, to 2) a more complex negative equative proposition, to 3) the most complex form where the two propositions in the problem are incongruent to each other. For these three types of syllogisms the following format was designed: 1) Two problems were set for the first type of simple syllogism, using the adjective better; 2) two problems were set for the more complex negative equative form, using the adjective worse; and 3) four problems were set for the most complex form where the two propositions are incongruent, using both adjectives better and worse.

In addition, these eight problems were repeated by replacing the adjectives better and worse by the comparative forms not as good as and not as bad as so that the total number of problems amounted to 16. Each stimulus problem was paired once with the question who is best? and once with the question who is worst? Thus, each version of the test contained 32 problems.

The Arabic version of the test was as similar a translated version of the English as could be obtained. An attempt was made to retain the same level of lexical and structural difficulty on the two versions.

All Ss received the same test. Half of the Ss in each group were tested first in Arabic then in English with the converse for the other half. In the initial briefing, Ss were told that the purpose of the study was to investigate their ability to solve problems of deductive reasoning via a weaker language in comparison with their performance on an equivalent set of problems in their mother tongue. They were told that they would be presented with a series of problems which they were to read carefully. Each problem would be followed by a question to which they were required to give an oral answer. The problems and the questions were printed on separate index cards which were shuffled before each trial. The Ss were instructed to place the stack of cards in front of them. The experimenter began timing with a manual stop watch when S turned over the first problem card; noted the time first when S turned over the question card, and again when S responded with one of the names. The two latencies -- for reading time and processing time -- and the response name were recorded separately for each problem.

Analysis of the Data

Mean latency scores for reading the problems and solving the problems, as well as error scores were computed for the three experi-

mental groups. Separate scores were tabulated for problems in Arabic and in English. A multivariate analysis of variance with repeated measures was carried out. The independent variable was group membership (ELI and FWC) and language (native language x second language) constituted the repeated measure. The dependent variables were error scores, latency scores for reading problems and latency scores for solving problems.

Results and Discussion

Table 5 shows the mean and variance observed for the 30 Ss. As in the previous study, the variance observed in the second language data is of the same order of magnitude as that in the native language data for both error scores and reading latencies. Once again, latency scores for solving problems show much greater variance (0.307: 3.58) for second language data than for native language data. It should be noted that the discrepancy between variance ratios in study two ($\sim$ 5:2) and the present study ($\sim$ 10:1) is likely attributable to the fact that the lower limit for measuring reaction times in this study was 1 sec. and data bunching occurred. However, the differential native language vs. second language effect seems again to be located in the second stage of the problem.

The observed means for each group are presented in Table 5.

Table 5

Overall Mean and Variance scores for latency and errors in native and second language

		Native (Arabic)		Second (English)
Comprehension latency (secs)	$\bar{X}$	20.96	$\bar{X}$	21.60
	σ^2	74.09	σ^2	50.23
No of errors	$\bar{X}$	4.733	$\bar{X}$	6.90
	σ^2	20.56	σ^2	23.49
Solution latency (secs)	$\bar{X}$	1.719	$\bar{X}$	2.443
	σ^2	.307	σ^2	3.58

The overall multivariate analysis indicated no significant relationship among the covariates and the dependent variables (latencies and errors). The low correlation coefficients may be due to the restricted range on the covariates.

The overall multivariate analysis of the repeated measures showed no significant difference between the ELI Ss and the FWC Ss. ($F = 1.9131$; $p = 0.1259$). In comparing these two groups there were neither significant group by language interactions nor group effects for any of the dependent variables indicating that the Ss' relative ability to solve problems in their first and second languages did not vary as a function of group membership (or second language proficiency), and that the Ss' overall ability to solve problems did not vary as a function of group membership. Multivariate and univariate tests indicated no significant main effect for language.

Table 6

Mean latency and error scores for two experimental groups in their native and second languages

N = 30
Native = Arabic
Second = English

	FWC N = 11	ELI N = 19
Comprehension latency - Native (secs)	15.94	23.88
Comprehension latency - Second (secs)	17.56	23.94
No of errors - Native	3.00	5.73
No of errors - Second	3.64	8.79
Solution latency - Native (secs)	1.28	1.97
Solution latency - Second (secs)	1.52	2.98

When native language and second language latency scores for solution were considered as a covariate in a step-down analysis, a significant effect (F step-down = 5.6328; $p \simeq 0.0257$) for language was noted for problem solving latencies. As observed in study two, working in the weaker language differentially affected the Ss performance at the second stage of the problems. These analyses should be interpreted as indicating, rather than confirming, that finding since the distributions of the solution scores in the second language are skewed with a long tail for greater latencies. Moreover, since the variances are different for maternal and second language solution latencies it might be interesting to reanalyse these data considering some transformation of the latency scores such as log latencies. Models involving the log latencies might be simpler to interpret than models involving raw data.

Summary and Conclusions

The pattern of results over the three studies was relatively stable in spite of differing experimental techniques and languages. The information processing difficulties in the second language noted in study one were brought into sharper focus in studies two and three. What conclusions can be drawn from this series of experiments? First our findings suggest that when we are dealing with cognitive processes as complex as those involved in reading or in problem-solving, we must attempt to look more closely at the component skills which underlie the particular task. Our Ss in studies two and three were equally good at comprehending the premises of deductive reasoning problems presented in both languages, but pulled apart at the second stage of the problem which called upon more demanding cognitive activities involved in the retrieval and manipulation of the stored information.

Secondly, these data provide empirical evidence that individual differences in general ability to perform a given task must be taken into consideration when statements are made regarding the relative ability of bilinguals to precess information in their two languages. This has proven to be important in the deductive reasoning task; it could be equally important in performance with the "cloze" technique. It is not clear from our studies whether such individual differences might be partially attributable to initial I.Q. differences among Ss. A recent paper by Oller (1977) suggests that there may be a close relationship between I.Q. (Spearman's g factor) and language processing abilities. Our studies did not take this factor into consideration since we felt that the experimental task was of a non-academic nature. The possibility that I.Q. might interact with second language proficiency to produce a threshold effect resulting in varying abilities to deal with information via a second language is worthy of consideration (Cummins, 1977b).

Thirdly, the data from our three studies suggest that the second language learner, or incipient bilingual's, relative ability to perform language related tasks in a second language, may not necessarily increase as a function of his proficiency as measured by discrete-point language tests. This point may be important since the assumption is often made that language proficiency tests are sound predictors of a bilingual's ability to be educated or to perform other tasks in a second language. The present research as well as studies reviewed by Dornic (1977) indicate that such assumptions may not be sound. Indeed various coping strategies deployed by the bilingual to handle second language materials may break down under stress, fatigue or when the individual is faced with particularly taxing information processing tasks.

We would like to conclude with a cautionary note which was prompted by a recent article by Mandler and Stern (1977). These authors point out the fragmentary nature and limitations of the data which have given rise to what they term "the myth of perceptual deficits". The point we wish to make is that the type of research which we have described is designed to increase our understanding of the manner in which second language learners or bilinguals perform a given task in their first and second languages. The effects which we have found are stable, interesting and intriguing, but we must recognize that they are still tentative and inconclusive. They may reflect individual differences in preferred modes of functioning, or cognitive style, areas which have scarcely begun to be investigated. These tentative data do not yet permit us to make any broad statements whatsoever about deficits, or handicaps, nor about the merits of native language or second language education.

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Appendix 1

Form of 16 stimulus problems used in Study One; each was paired once with "Who is best?" and once with "Who is worst?".

I	(a)	A better than B; B better than C
	(b)	B better than C; A better than B
II	(a)	C worse than B; B worse than A
	(b)	B worse than A; C worse than B
III	(a)	A better than B; C worse than B
	(b)	C worse than B; A better than B
IV	(a)	B worse than A; B better than C
	(b)	B better than C; B worse than A
I'	(a)	A not as bad as B; B not as bad as C
	(b)	B not as bad as C; A not as bad as B
II'	(a)	C not as good as B; B not as good as A
	(b)	B not as good as A; C not as good as B
III'	(a)	A not as bad as B; C not as good as B
	(b)	C not as good as B; A not as bad as B
VI'	(a)	B not as good as A; B not as good as C
	(b)	B not as bad as C; B not as good as A